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ABD'DE HAM PETROL FİYATLARI DİZEL FİYATLARINI NASIL ETKİLEMEKTEDİR: ARDL YAKLAŞIMI İLE AMPİRİK ANALİZ

Şebnem Çoban[1]

ÖZ

Bu araştırmada, ham petrol ve dizel fiyatları arasındaki ilişkiyi incelemek için log-doğrusal model üzerinde derinlemesine bir analiz yapılmıştır. Genel olarak, bu değişkenler arasında benzer davranış gözlenebilir. Bu amaçla, serilerin sabit veya durağan olup olmadığını incelemek için log-doğrusal modelin zaman serisi verileri üzerinde birim kök analizi yapılmıştır. Serilerin ayrıca, birlikte entegre olup olmadıklarını gözlemlemek ve ortak stokastik eğilimi paylaşıp paylaşmadıklarını anlamak için Engle-Granger Eşbütünleşme testi kullanılarak analiz edilmişlerdir. Ayrıca, bu çalışmada uzun dönemli ilişkiyi incelemek için ARDL (Dağıtılmış gecikme ve otoregresiv) analizi de yapılmıştır. Bu analizde Nisan 1994 ve Ekim 2017 arasında ABD ham petrol ve dizel fiyatları arasındaki aylık zaman serisi verileri kullanılmıştır. Ampirik sonuçlar, dizel ve ham petrol fiyatlarının aynı eğilime sahip olduğunu ve zaman içinde benzer şekilde hareket ettiğini ve uzun vadeli ilişkinin de var olduğuna dair bir kanıt olduğunu açıkça göstermektedir.

Anahtar Kelimeler: ham petrol, dizel, log-doğrusal model, birim kök, eş bütünleşme, ARDL

Jel Kodları: M2, C8, C22

[1] *Eastern Mediterranean University, IT, sebnem.coban@emu.edu.tr*

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HOW CRUDE OIL PRICES AFFECT DIESEL PRICES IN UNITED STATES: AN EMPIRICAL ANALYSIS USING ARDL APPROACH

ABSTRACT

In this research, an in-depth analysis was conducted on log-linear model in order to examine the relationship between the crude oil and diesel prices. Generally, similar behavior may be observed between these variables. For this purpose, unit root analysis was conducted on time series data of log-linear model to examine if the series are stationary or non-stationary. The series also were analyzed using Engle-Granger Cointegration test to observe if they were co-integrated, and share the common stochastic trend. Moreover, ARDL (Autoregressive distributed lag) analysis was also conducted to examine the long-run relationship in this study. Monthly time series data between April 1994 and October 2017 of US crude oil and diesel prices have been used in this analysis. Empirical results clearly show that, the diesel and crude oil prices have the same trend and move in a similar way in time and there is an evidence that long-run relationship also exist.

Keywords: crude oil, diesel, log-linear model, unit root, co-integration, ARDL

Jel Classification: M2, C8, C22

INTRODUCTION

Economic theory suggests that the derivatives of a raw material are expected to be co-integrated with the core material. When crude oil is refined, it produces several products namely, gasoline, heavy oil, diesel and other petroleum products. Even if all the markets are very competitive, so that the average of the prices for these products follows the crude oil price very closely (Bacon, 1990).

Fluctuations in the price of crude oil have an influence on the costs of transportation, and manufacturing. The capacity that crude oil generate economic crises such as the ones occurred in 1973, 1979 and 1990, it is significant to national economies as well as commercial markets (Block, Righi, Schlender, and Coronel, 2015). According to the most of the empirical analysis and theoretical context, crude oil and its products show a robust correlation. According to Brown and Yücel (2008), there is a strong confirmation that oil prices affect US gas prices, and other independent variables, and also the researchers found a close relationship that oil prices affect US gas prices and then they concluded that the natural gas prices are determined by crude oil prices.

There are many factors affecting the price of crude oil and its products. Some of the factors include, economic crises, financial crises, weather conditions (e.g. hurricanes, typhoons, etc.), and world war. The biggest increase in price of oil and other commodities was experienced in 2007-2008 in postwar period (Hamilton, 2011). Due to the devastating factors, there might be insufficient data or huge fluctuations in the prices. Some previous studies have found indication of a long run relationship between crude oil and its products, but due to the missing data, there was an inconsistent result of the strength of the association between these products (Myers, Johnson, Helmar, and Baumes, 2015).

In this research paper, the most recent data, which includes monthly time series between the periods April 1994 and September 2017 of US crude oil and diesel prices, is employed. Linear and log-linear models are examined in order to understand the relationship between the crude oil and diesel prices. However, the results of only the log-linear model are discussed in this paper.

The results will help us to understand the trend of data, and how they move in time. As a first step the Augmented Dicky Fuller (ADF) tests will be applied on time series data of the model to check whether the model has unit root and the series are stationary or non-stationary. In case of non-stationary, Engle-Granger Cointegration test then will be applied to check whether they share the common stochastic trend or not. Moreover, ARDL and Bounds tests using Akaike Info Criterion (AIC) and Schwarz Criterion (SC) methods will also be applied and long-run results will be included in this paper. In order to test if the economic theory is satisfied, the results are analyzed empirically.

Finally, the rest of the article includes the review of literature, description of the data, models and the methodology, results of empirical analysis as well as the interpretations of the results and the conclusion.

1. LITERATURE REVIEW

In the previous studies, oil prices became major concentration for most of the scholars in the economic literature. There are many investigations with respect to understand the connection between the prices of crude oil, its derivatives, supplements, complements and other commodities. Although some of the researchers examined short run and long run relationships between the prices of the commodities, some others focused on asymmetric relationship. Economic shocks also considered by most of the investigators in order to analyze the data in specific time period (Hamilton, 2011; Pokrivcak and Rajcaniova, 2011; Wadud, Graham, and Noland, 2009).

Pokrivcak and Rajcaniova (2011) analyzed the statistical relationship between crude oil, gasoline and ethanol prices to examine the correlation and the linear relationship among the variables by investigating weekly data from January 2000 to October 2009 in Germany. Vector Auto Regression (VAR) and the Impulse Response Function (IRF) were used to measure how a variable was linked to another variable. The findings of the research indicated that oil and gasoline prices were co-integrated; however, the prices of ethanol and gasoline as well as ethanol and oil had no relationship.

Researchers, Karagiannis, Panagoloulos, and Vlamis (2015), had studied the short run and long run relationships between the crude oil and retail gasoline prices, by conducting the hypothesis of symmetry price adjustments. In this research, weekly retail fuel prices for Germany, France, Italy and Spain were collected which cover the period 2002 and 2011. Researchers then applied Error Correction Model (ECM) to estimate the transition of international crude oil price and symmetric or asymmetric behavior of the fuel price changes, but the results do not verify that the “rockets and feathers” hypothesis was sustained.

Moutinho, Bento, and Hajko (2017), investigated the bond among the crude oil price and consumer prices of transport fuels in 2008 before and after the financial crises in the European Union. According to the economic theory, input and output prices of products should be in a close relationship. The researchers did short-term and long-term analysis by using weekly data between crude oil prices and consumer prices of gasoline, diesel, and auto gas. Findings of this study includes that cointegration exists between crude oil, gasoline, diesel fuel, and auto gas prices and they share the common stochastic trend.

On the other hand, Atil, Lahiani, and Nguyen (2014), formed nonlinear autoregressive distributed lags (NARDL) model to study the transition of crude oil prices into gasoline and natural gas prices. The researchers measured the short and long run non-linearities, and the reaction of gasoline and natural gas prices to asymmetric behavior of oil price shocks. The results of this research indicates that gasoline prices were getting affected by the crude oil prices in a non-linear and an asymmetric way, but no positive observation was found regarding the price transition.

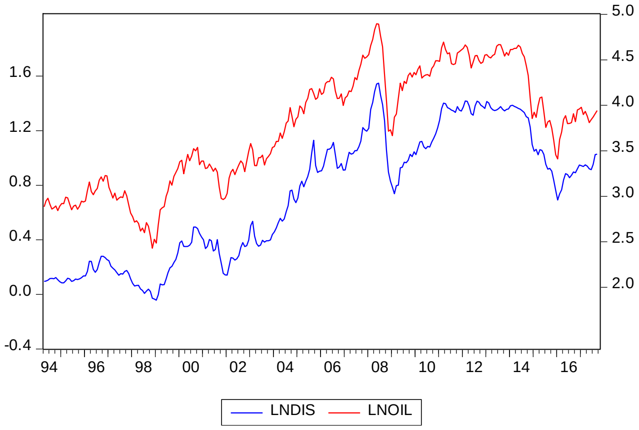
In summary, most of the researchers focused on the asymmetric relationship between the prices of crude oil and other commodities by conducting short and long run analysis. Numerous researchers provided co-integration between the commodities that show same stochastic trend among the variables. Some others investigated pass-through connection between the crude oil, its products and substitutes.

2. DATA, MODEL AND THE METHODOLOGY

2.1 Data

In this study, spot price of WTI crude oil (dollars per barrel) and retail prices of diesel (dollars per gallon) are analyzed. The datasets are downloaded from the U.S. Energy Information Administration web site, which covers the monthly time series including 280 observations that ranges from April 1994 to September 2017. Figure 1 shows the plot of data in time, which represent the logarithmic format of the corresponding time series data. The figure illustrates that the data is non-stationary.

Figure 1 - Crude Oil and Diesel Log prices between April 1994 and September 2017



2.2 Model

To analyze the relationship between crude oil and diesel prices log-linear model is formed as seen equation below.

$$lnP_t^{dis} = \beta_0 + \beta_1 lnP_t^{oil} + u_t ,$$

In the model, $\mathbf{lnP_t^{dis}}$ and $\mathbf{lnP_t^{oil}}$ represent logarithmic price of diesel, and crude oil correspondingly. The variables in this model then were converted into their natural logarithmic forms, and were analyzed, since they have different measurement units (dollars per barrel and dollars per gallon respectively). Instantaneous growth rate of coefficients were expected to be obtained after log-linear model was estimated. This means that, there will be constant elasticity relationship between variables $\mathbf{lnP_t^{dis}}$ and $\mathbf{lnP_t^{oil}}$. Log-linear relationship of variables according to the provided model assume that a 1 percent increase in $\mathbf{lnP_t^{oil}}$ leads to $\boldsymbol{\beta_1}$ percent change in $\mathbf{lnP_t^{dis}}$ (Dranove, 2012).

2.3 Methodology

Commonly the combination of non-stationary time series are said to be non-stationary, however, in case of stationary of the combination of non-stationary time series is a unique situation, which is known as co-integration Nielsen (2017).

Primary condition of co-integration test is that the variables of time series must have the same order of integration (Bakhat and Würzburg, 2013). Prior to estimating the linear and log-linear models, Augmented Dicky Fuller (ADF) unit root test is conducted for the model and the results are provided in Table 1. Then, the test for co-integration, Engle-Granger approach is used and the result is presented in Table 2. Ordinary Least Squares (OLS) results of both models, which is the method of linear regression, helps us to better predict the correlation between the dependent and independent variables. OLS results are presented in Table 3 and will be explained later in the next section.

Table 1. Unit root test results of Log-Linear Model

Variables	ADF Tests			
	Level		First Difference	
	Without Trend	With Trend	Without Trend	With Trend
LNDIS	-1.426238 [0.5964]	-2.252411 [0.4582]	-10.28584 [0.0000]	-10.28794 [0.0000]
LNOIL	-1.693962 [0.4333]	-2.058578 [0.5661]	-12.83522 [0.0000]	-12.83102 [0.0000]

On the other hand, Bentzen and Engsted (2001), indicated that autoregressive distributed lag model (ARDL) is the most commonly used model for the estimations of time-series energy demand relationships. ARDL model should be applied when the variables are non-stationary and not co-integrated, even if the variables are co-integrated the result might not be valid. The results were expected to be non-stationary for the energy economic variables; however, the model should not be rejected before ARDL test was applied. According to Pesaran, Shin, and Smith (2001), bounds testing should be applied when the variables provide critical value bounds for all classifications of all the explanatory (regressors) variables into purely I(0), I(1) or mutually co-integrated. Moreover, Giles (2013) states in his blog that, the autoregressive model is dependent variable and is explained by lagged values of itself and also has a distributed lag component in the consecutive lags form of associated explanatory variables.

Giles (2013) also indicated in his another post that in order to implement ARDL model Bounds Tests were used to examine if the long-run relationship exits when two non-stationary time-series were grouped.

Table 2. Engle-Granger Co-integration Test Results

Variable	**Variable**	**tau-statistic [Prob]**
DIS	*LNDIS*	*-4.001829 [0.0081]*
OIL	*LNOIL*	*-4.105512 [0.0058]*

Therefore, in this study, Bounds Testing is applied on both models (linear and log-linear) to investigate the long-run relationships of the time-series. Additionally the results obtained from OLS and Bounds tests will be compared and the interpretation will be added in order to conclude the results.

3. RESULTS

3.1 Unit Root Tests

ADF tests are applied on each of the variables of log-linear model in order to test for their level and first difference stationarity and the results are summarized in Table 1. In the model when unit root test is done with trend and without trend, because of high prob values, Null Hypothesis cannot be rejected. Variables of the model have a unit root. Therefore data are said to be non-stationary. On the other hand, test results indicate that we have stationary data when we repeat the tests on the first difference of each series, since the prob values are leading to zero (0). Therefore, the Null Hypothesis can be rejected.

3.2 Engle-Granger Cointegration Analysis

The aim of conducting Engle-Granger test is to check if the series are co-integrated and share the common stochastic trend. The results of the log-linear model emphasize that the series are co-integrated.

Table 3. Results of Ordinary Least Squares (OLS)

Log-Linear Model - The equation:	
$LNDIS_t = -2.009458 + 0.728212 LNOIL_t$	
t-stat (lnoil)	***Prob***
82.73538	*0.0000*
R-squared	*0.960703*

As Table 3 provides the summary of the results of OLS estimations, log-linear model shows that 1% increase in crude oil price leads to 0.73 % increase in diesel price. The meaning of the coefficients of variable in the model is statistically significant since the Prob value leads to 0.0000. R-squared (R^2)

value of log-linear model is 0.96, which indicate that the model is highly statistically significant. Finally, Durbin-Watson results suggest that there might be serious auto correlation problem in the model, which is due to the number of observed values are over 288.

3.3 ARDL Models and Bounds Testing Results

Log-linear model is tested based on Akaike Information Criterion (AIC) and Schwarz Criterion (SC) methods in order to estimate ARDL models. According to selected models[1] ARDL(9,4), ARDL(1,2) (log-linear model), the R-squared (R^2) values are close to one (1) and Prob (F-statistic) values are leading to 0 (zero) we can conclude that all ARDL models are meaningful. Furthermore, since the value of Durbin-Watson is around two (2) is an indication that autocorrelation does not exist.

Additionally, long-run relationship serial auto-correlation test is conduct for the model and presented in Table 4. The results indicate that there is no evidence of autocorrelation since Null Hypothesis (H_0) cannot be rejected at 5% level.

Table 4. Bounds Tests for Linear and Log-Linear Models (AIC and SC)

F-Bound Test				
F-Statistic	**Value**	**Signif.**	**I(0)**	**I(1)**
		10%	3.113	3.61
		5%	3.74	4.303
		1%	5.157	5.917
Log-Linear Model				
(AIC)	3.664084	**(SC)**	6.976621	

Table 5. Comparison of OLS and Bounds Test results (Log-Linear Model)

Log-Linear Model - OLS:	**Log-Linear Model – Bounds Test: (AIC)**
$LNDIS_t = -2.009458 + 0.728212 LNOIL_t$	$LNDIS_t = -2.160969 + 0.773029 LNOIL_t$
t-stat (oil)	***t-stat (lnoil)***
82.73538	*20.61552*

Akinboade, Ziramba, and Kumo (2008) explained that the null hypothesis of co-integration by means of F-test. The researchers indicate that for different model specifications, two bounds of critical values are developed. I(1), upper bound is applied when all variables are co-integrated and I(0), lower bound is applied when all variables are stationary. In this study, Bounds Tests based on AIC and SC methods applied and the results are obtained, which are provided in Table 4. According to the selected models ARDL(9,4), ARDL(1,2), since the F-statistic values of all results of selected models exceed the upper bound I(1) we can conclude that the variables in log-linear model are co-integrated at 5% and even 10% levels.

Finally, OLS and Bounds test results are compared and the results indicate that coefficient of the model is highly statistically significant and there is a strong evidence for a positive correlation between the variables in long-term.

CONCLUSION

In this study, the relationship between crude oil and diesel prices was examined. In order to conduct the analysis, monthly data for each variable from April 1994 to September 2017 was used. Subsequently, log-linear model was formed in which to include crude oil prices as an independent variable and diesel prices as a dependent variable. As mentioned earlier, economic theory suggests that, the fluctuations in crude oil prices should be followed by a common trend by its derivatives such as heavy oil, gasoline, diesel and etc. The empirical analysis results justify that there is a co-integration relationship between the crude oil and diesel prices. ARDL model and bounds tests have been conducted in order to study the long run relationships between the variables. Comparison between OLS results and bounds test results is another important finding that the long run relationship between the variables (crude oil and diesel) exists. The main contribution of this work is the use of the most recent data in order to justify the previous research studies.

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